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(21) International Application Number: PCT/SE97/00497 (22) International Filing Date: 24 March 1997 (24.03.97) (30) Priority Data: 9601619-1 29 April 1996 (29.04.96) SE (71) Applicant (for all designated States except US): RADIO DESIGN INNOVATION AB [SE/SE]; P.O. Box 1223, S-164 28 Kista (SE). (72) Inventors; and (75) Inventors/Applicants (for US only): JOHNSON, Torbjörn [SE/SE]; Lidvägen 1, S-175 40 Järfälla (SE). MALMGREN, Jens [SE/SE]; Heleneborgsgatan 6 C, S-117 32 Stockholm (SE). (74) Agents: HOLMQVIST, Lars, J., H. et al.; Albihn Holmqvist AB, P.O. Box 4289, S-203 14 Malmö (SE).		(81) Designated States: AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, CA, CH, CN, CU, CZ, DE, DK, EE, ES, FI, GB, GE, GH, HU, IL, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MD, MG, MK, MN, MW, MX, NO, NZ, PL, PT, RO, RU, SD, SE, SG, SI, SK, TJ, TM, TR, TT, UA, UG, US, UZ, VN, YU, ARIPO patent (GH, KE, LS, MW, SD, SZ, UG), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, CH, DE, DK, ES, FI, FR, GB, GR, IE, IT, LU, MC, NL, PT, SE), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, ML, MR, NE, SN, TD, TG). Published <i>With international search report.</i> <i>Before the expiration of the time limit for amending the claims and to be republished in the event of the receipt of amendments.</i>
(54) Title: TRANSMITTER COMBINER ARRANGEMENT (57) Abstract <p>The invention relates to a transmitter combiner arrangement, and more specifically a transmitter combiner arrangement usable in communication systems transmitting signals with a wide dynamic range, e.g. in a base station of a multilobe telecommunication system having phased array antennas. The transmitter arrangement according to the invention enables amplification of low and high levels with high efficiency by means of a hybride arrangement comprising a hybride of progressively coupled single carrier power amplifiers (SCPA) and a multicarrier power amplifier (MCPA) connected with a combiner network.</p>		

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TITLE OF INVENTION: TRANSMITTER COMBINER ARRANGEMENT

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FIELD OF THE INVENTION

The present invention relates to a transmitter combiner arrangement, and more specifically a transmitter combiner arrangement usable in a base station of a multilobe telecommunication system having phased array antennas. However, the invention is not limited to such a system, but is very useful with systems having a large dynamic range, e.g. up to 110 dB or more. The transmitter arrangement according to the invention enables amplification of low and high levels with high efficiency by means of a hybride arrangement combining efficient single carrier power amplifiers (SCPA) and high power multicarrier power amplifiers (MCPA).

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STATE OF THE ART

Single carrier power amplifiers are known amplifier circuits having high efficiency at maximum output power but are, of course, used for only one carrier frequency at a time. Today it is conventional to combine such SCPAs with filter combiners. It is also conventional to use SCPAs with 3 dB combiners. However, power is lost in the combiner resulting in low efficiency and high current consumption, which means high costs.

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The multicarrier power amplifier is a known amplifying circuit having high power but low efficiency. The advantage of this circuit is that it may accomodate many channels. However, they are expensive and difficult to implement when different carriers are at different levels, such as when power control is used or in phased array antennas.

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The problems stated above are solved by the present invention by using single carrier power amplifiers in a

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progressive coupling, which enhances efficiency compared to a 3 dB combiner amplifier. This is combined with a multi-carrier power amplifier for lower power carriers. This reduces costs significantly compared to high power MCPA. For enhanced capacity the invention features an expansion input.

SUMMARY OF THE INVENTION

Thus, the present invention provides a transmitter combiner arrangement comprising a hybride of progressively coupled single carrier power amplifiers and a multicarrier power amplifier connected with a combiner network.

The invention is set forth in detail in the accompanying claims.

BRIEF DESCRIPTION OF THE DRAWINGS

The invention is described below with reference to the accompanying drawings, in which

Figure 1 is a block diagram of a first embodiment of the invention including progressively coupled single carrier power amplifiers and a multicarrier power amplifier connected by a combiner network;

Figure 2 is a block diagram of another embodiment of the invention in which single carrier power amplifiers are connected by a filter bank;

Figure 3 is a block diagram of a further embodiment of the invention in which single carrier power amplifiers are connected by the filter bank and a 3 dB combiner;

Figure 4A is a block diagram of a preferred embodiment of a single carrier power amplifier according to the invention; and

Figure 4B is a block diagram of a possible implementation of a single carrier power amplifier.

DETAILED DESCRIPTION OF PREFERRED EMBODIMENTS

As is mentioned above, the transmitter combiner arrangement according to the present invention is suitable for use in communication systems that transmit signals with a wide dynamic range. In a multilobe system with a phased array antenna, the power is distributed to many radiating elements, and in order to obtain low sidelobe levels, the

power sent to the different radiating elements may vary 30 dB. In a base station, it is also desirable to use power control in order not to send out more power than necessary, the usable power being about 80 dB. This leads to a requirement for dynamic range of 110 dB. As the requirement for suppression of intermodulation is 60-70 dB depending on the application, the requirement for intermodulation product suppression with this dynamic range is 170-180 dB, which is not achievable with an ordinary MCPA.

10 The base station includes a lobe-shaping unit for controlling the signals to the phased array antenna. A base station controller in turn controls the base stations of the telecommunication system. The lobe-shaping unit and the base station controller do not form any parts of the present invention.

In Figure 1 is shown a preferred embodiment of the present invention. As may be seen the transmitter arrangement includes a number of SCPAs connected by transmitter combiner circuits WILKD3DB, which may be of the conventional Wilkinson 3dB type, in a step arrangement having equal attenuation steps. Thus, the top SCPA will be able to furnish the lowest output power. In front of the SCPAs are variable attenuators VVA. The inputs to the various SCPAs are arranged according to the input level or power requirement, such that the correct output power is obtained at the output.

At the top transmitter combiner is a further expansion input for additional low power channels.

The transmitter arrangement also comprises a multi-carrier power amplifier. In front of the MCPAs is a combiner network, which may consist of transmitter combiners or a resistive combiner network. The combiner network is preferably symmetrical, such that the gain through the amplifiers is the same independent of input port. The MCPA is suitable for amplifying many low levels since these will not generate important intermodulation products.

35 The SCPAs and the MCPA are combined in a final transmitter combiner.

At the output of the MCPA is a detector for providing information to a control unit. The control unit controls the various amplifier units of the SCPAs and the MCPA by pro-

viding the correct input voltage and input currents, i.e. the bias of the amplifier units. Thus the efficiency of the amplifiers can be optimised. The control unit also receives input information from a base site controller and a lobe-
5 shaping unit, if the transmitter combiner arrangement according to the invention forms part of such a telecommunication system.

In Figure 2 is shown another embodiment of the present invention. In this embodiment the SCPAs are connected by a
10 filter bank to the final transmitter combiner. The filters of the filter bank are connected by $\lambda/4$ and $\lambda/2$ transmission lines to the combiner for correct addition at the combiner.

In Figure 3 is shown an embodiment of the invention featuring only SCPAs combined with filters. This embodiment
15 is useful when it is desired to amplify many similar high level signals. It is especially advantageous with a preferred embodiment of a single carrier power amplifier according to the present invention as described below with reference to Figures 4A and B.

20 In Figure 4A is shown an especially advantageous form of a single carrier power amplifier having variable power and amplification levels. As may be seen, the amplifier comprises a number of amplifier units AMP which may be enabled by setting a corresponding number of switches. The
25 amplifier unit at the far left can only output low signal levels. When a higher signal levels are required, the middle amplifier is also enabled as it can supply medium output levels. At high output levels, also the amplifier unit at the far right is enabled being able to supply high output
30 levels. When the middle or right-hand amplifiers are disabled, their biases are turned off so that the power consumption is considerably reduced and the signal is bypassed. With this arrangement, the efficiency of the amplifier is maintained fairly independent of the output
35 signal level. Also, the amplifier arrangement achieves 60 dB gain control. This is achieved by varying the bias of the amplifiers. A voltage variable attenuator VVA is used to fine tune the gain.

Figure 4B shows a possible implementation of the
40 amplifier circuit including switchable PIN diodes and $\lambda/4$

transmission lines MTRL.

The present invention has been described with reference to the disclosed embodiments in great detail. However, many variations and modifications of the embodiments may be appreciated by a person skilled in the art. The invention is only restricted by the scope of the claims below.

CLAIMS

1. A transmitter combiner arrangement, **characterised** by a hybrid of progressively coupled single carrier power amplifiers (SCPA) and a multicarrier power amplifier (MCPA) connected with a combiner network.

2. A transmitter combiner arrangement according to claim 1, **characterised** in that the single carrier power amplifiers are coupled in equal steps by transmitter combiners, e.g. of Wilkinson type.

3. A transmitter combiner arrangement according to claim 1 or 2, **characterised** in that the combiner network of the multicarrier power amplifier is symmetrical for equal amplification of the multicarrier power amplifier channels.

4. A transmitter combiner arrangement according to any one of claims 1 to 3, **characterised** by having an expansion input for adding more single carrier power amplifiers.

5. A transmitter combiner arrangement according to any one of the preceding claims, **characterised** by a control unit receiving information from a detector connected to the outputs of the single carrier power amplifiers and the multicarrier power amplifier for controlling the bias of the amplifier units of the single carrier power amplifiers and the multicarrier power amplifier.

6. A transmitter combiner arrangement according to claim 5, **characterised** in that the control unit receives information from a base site controller (BSC) and/or a lobe shaping unit of a multilobe telecommunication system.

7. A transmitter combiner arrangement, **characterised** by a hybrid of single carrier power amplifiers (SCPA) coupled by a filter bank and a multicarrier power amplifier (MCPA) connected with a combiner network.

8. A single carrier power amplifier, **characterised** by an assembly of a plurality of amplifier units having a high efficiency for varying input levels, wherein the amplifier units are enabled progressively by switches for varying output powers.

9. A single carrier power amplifier according to claim 8, **characterised** in that the switches of the amplifier circuit include switchable PIN diodes and $\lambda/4$ transmission lines (MTRL).

10. A transmitter combiner arrangement according to any one of claims 1 to 7, characterised by a single carrier power amplifier according to claims 8 or 9.

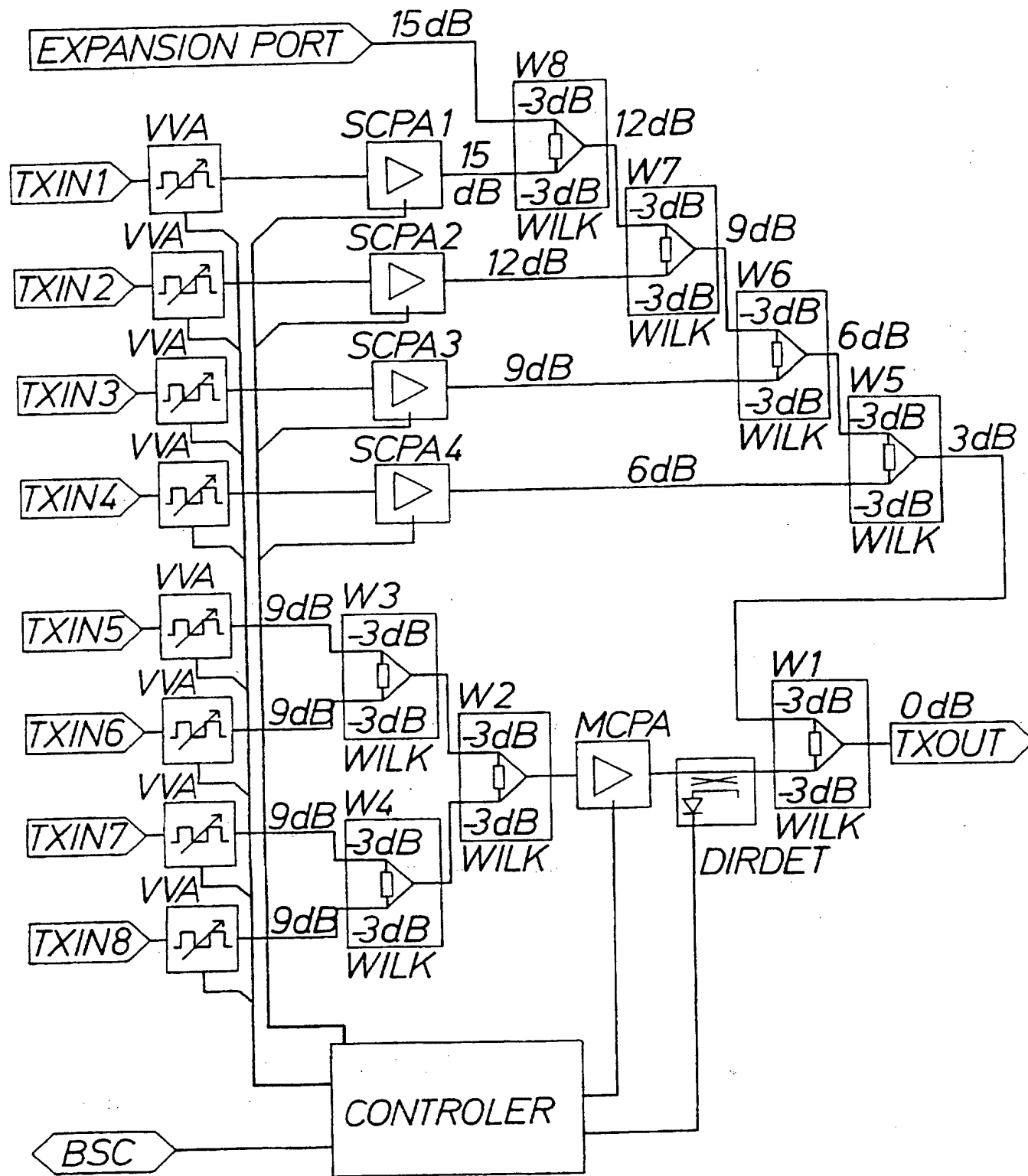


FIG. 1

SUBSTITUTE SHEET

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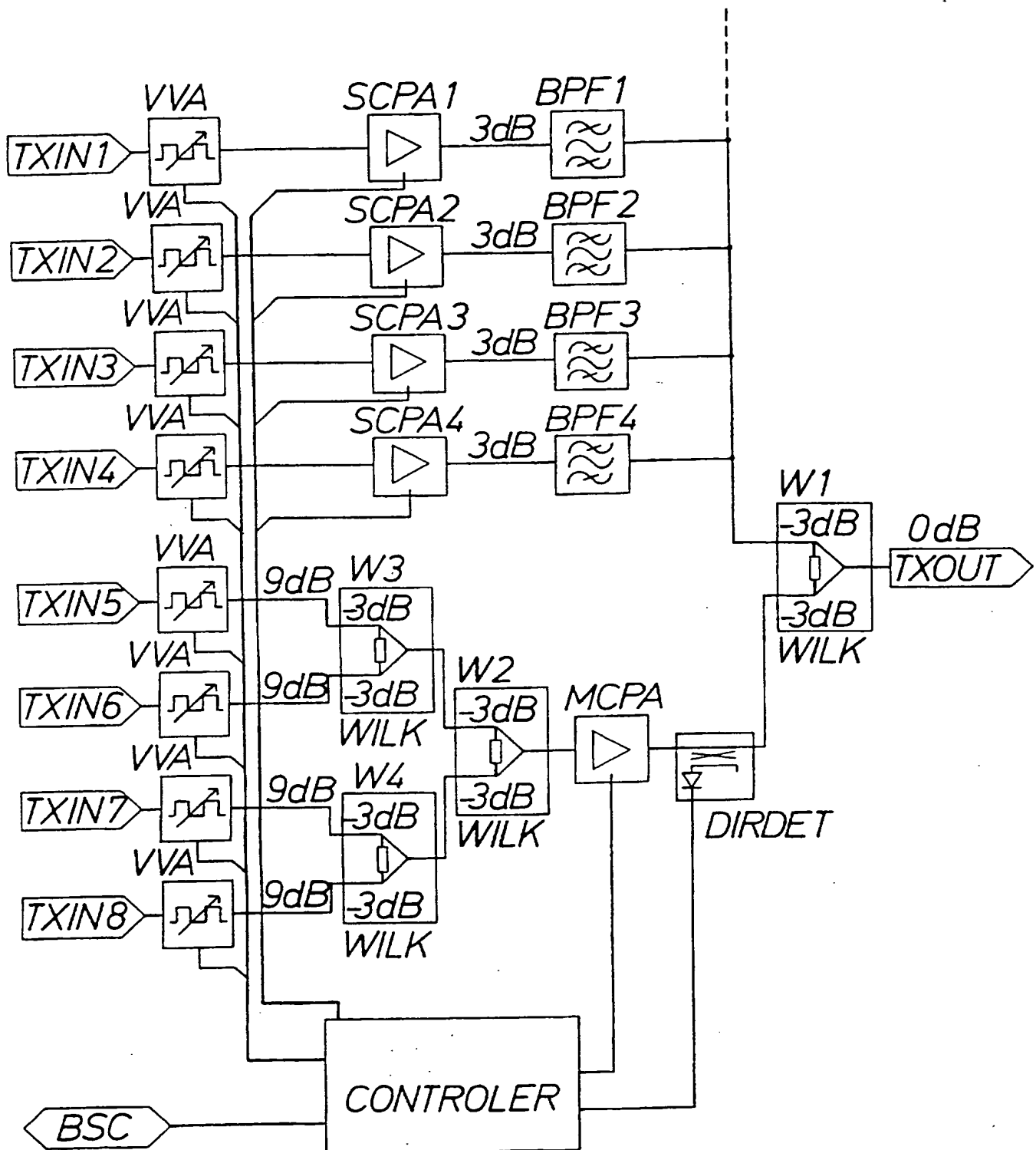


FIG. 2

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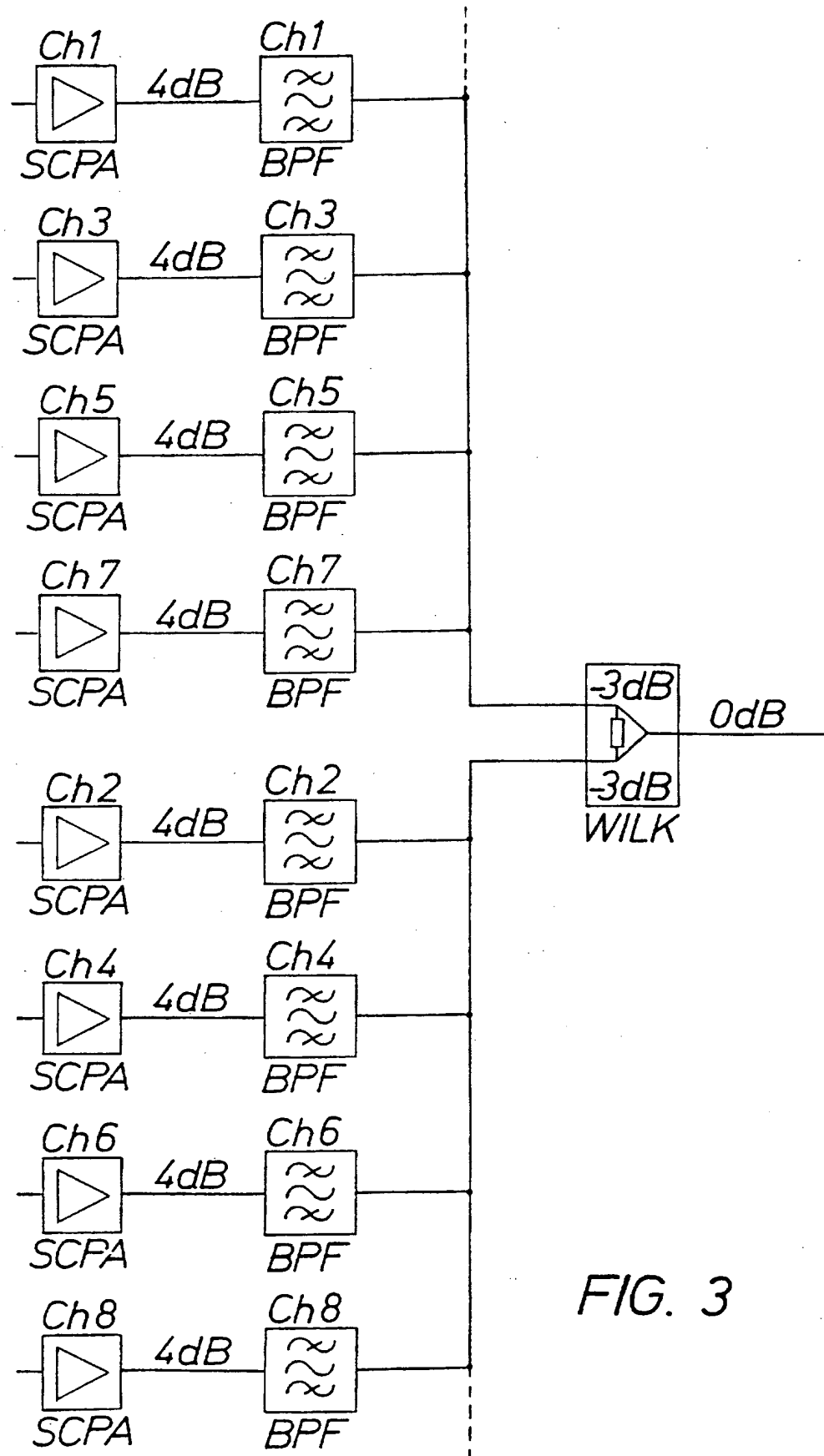


FIG. 3

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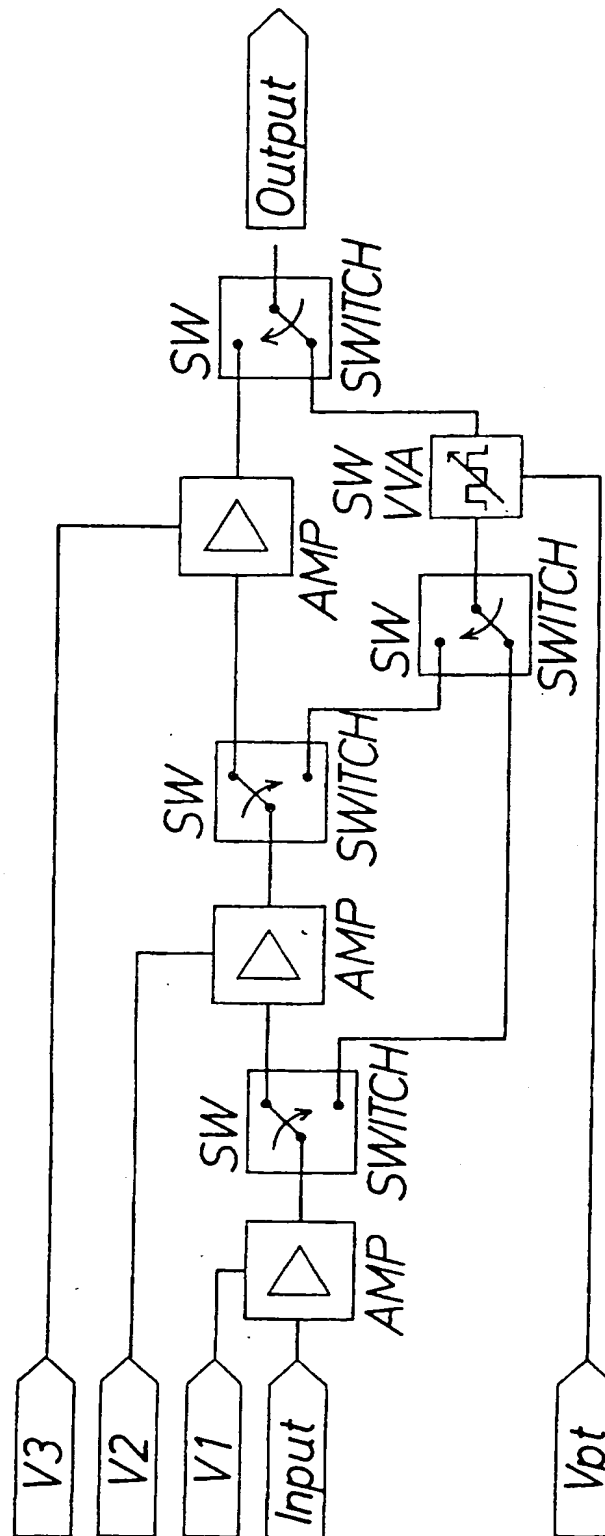
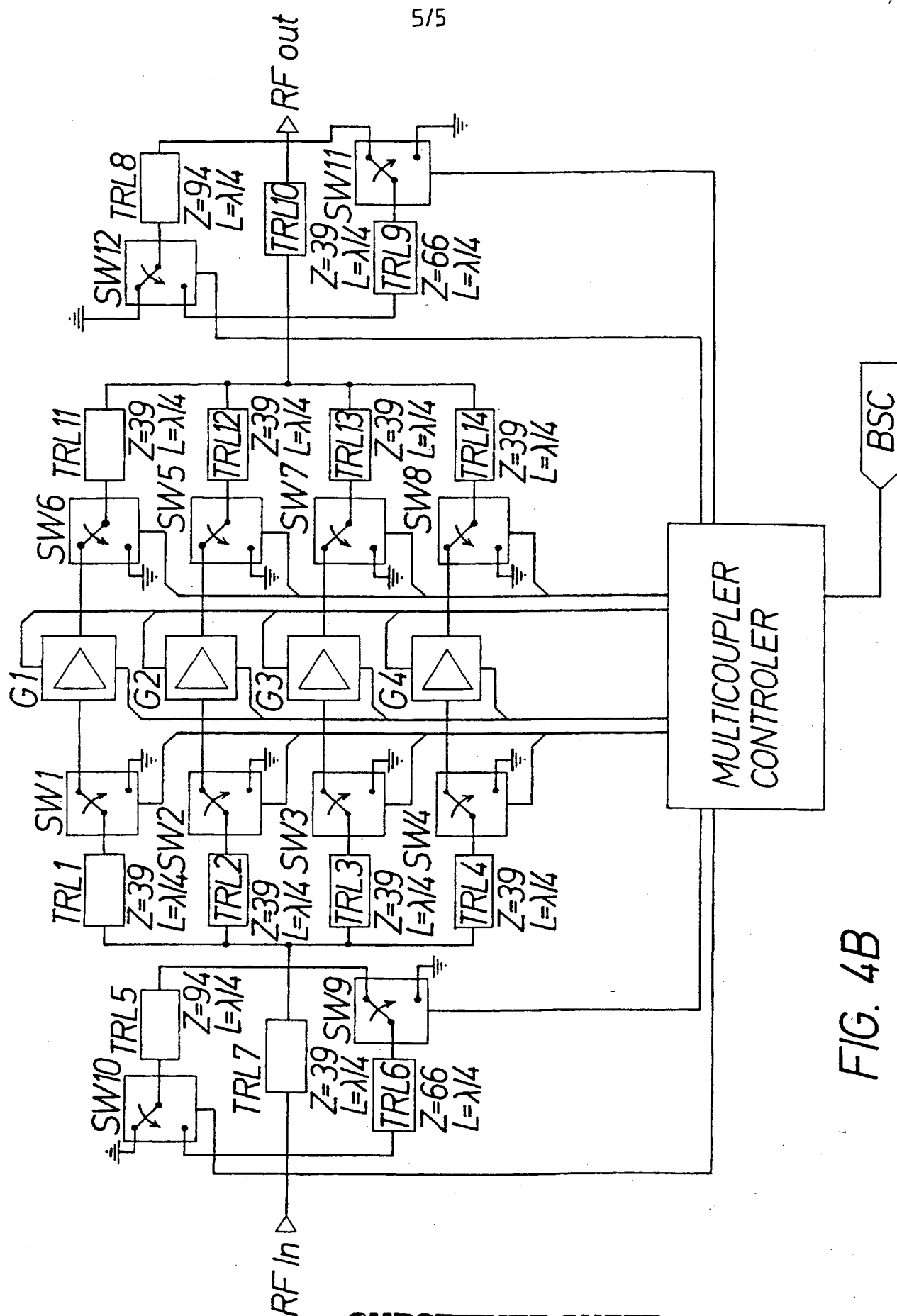


FIG. 4A

SUBSTITUTE SHEET



SUBSTITUTE SHEET

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 97/00497

A. CLASSIFICATION OF SUBJECT MATTER		
IPC6: H04B 1/02, H04B 7/005, H01Q 3/00, H03F 1/02, H03G 3/20 According to International Patent Classification (IPC) or to both national classification and IPC		
B. FIELDS SEARCHED		
Minimum documentation searched (classification system followed by classification symbols)		
IPC6: H04B, H04L, H01Q, H03F, H03G		
Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched		
SE,DK,FI,NO classes as above		
Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)		
C. DOCUMENTS CONSIDERED TO BE RELEVANT		
Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 5257415 A (YOSHIAKI KUMAGAI ET AL), 26 October 1993 (26.10.93), column 3, line 34 - column 4, line 32 --	1-7, 10
A	EP 0395239 A1 (HUGHES AIRCRAFT COMPANY), 31 October 1990 (31.10.90), column 5, line 14 - column 6, line 57, figure 1 --	1-7, 10
A	EP 0462699 A2 (BRITISH AEROSPACE PUBLIC LIMITED COMPANY), 27 December 1991 (27.12.91), abstract --	1
<input checked="" type="checkbox"/> Further documents are listed in the continuation of Box C. <input checked="" type="checkbox"/> See patent family annex.		
* Special categories of cited documents: "A" document defining the general state of the art which is not considered to be of particular relevance "B" earlier document but published on or after the international filing date "L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified) "O" document referring to an oral disclosure, use, exhibition or other means "P" document published prior to the international filing date but later than the priority date claimed "T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention "X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone "Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art "&" document member of the same patent family		
Date of the actual completion of the international search		Date of mailing of the international search report
10 Sept 1997		12 -09- 1997
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International application No.

PCT/SE 97/00497

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
A	US 3735289 A (WARREN B. BRUENE), 22 May 1973 (22.05.73), column 1, line 4 - line 41 --	1
X	EP 0665657 A2 (MOTOROLA LTD), 2 August 1995 (02.08.95), column 8, line 45 - line 56, figure 5 --	8,9
X	US 5113192 A (BOBBY J. THOMAS), 12 May 1992 (12.05.92), column 4, line 40 - column 5, line 1, figure 2 --	8,9
P,X	EP 0735668 A1 (AT & T IPM CORP.), 2 October 1996 (02.10.96), column 5, line 28 - line 57, figure 5, abstract --	8,9
P,A	WO 9636105 A1 (FUJITSU COMPOUND SEMICONDUCTOR, INC.), 14 November 1996 (14.11.96), page 2, line 5 - line 24; page 3, line 26 - page 5, line 2, figures 2A,2B ----- --	8,9

INTERNATIONAL SEARCH REPORT

International application No.

PCT/SE 97/00497

Box I Observations where certain claims were found unsearchable (Continuation of Item 1 of first sheet)

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of Item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:

See extra sheet.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.
2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.
3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark on Protest

☐
☐

The additional search fees were accompanied by the applicant's protest.

No protest accompanied the payment of additional search fees.

INTERNATIONAL SEARCH REPORT

International Application No

PCT/SE 97/00497

The claimed invention relates to circuit arrangement in a transmitter unit. The arrangement comprises single carrier power amplifiers (SCPA) and multicarrier power amplifiers (MCPA) connected with a combiner network.

The claimed invention according to claim 1 relates a transmitter combiner arrangement comprising a hybrid of a progressively coupled SCPA and a MCPA connected with a combiner arrangement. No technical features characterising said SCPA or MCPA is given in claim 1.

The invention claimed in claim 8 relates to a SCPA characterised by certain technical features. The characterising technical features given by claim 8 is not specified in claim 1.

Thus, claim 1 relates to a transmitter combiner arrangement and claim 8 relates to a power amplifier. Consequently, the application can not be considered to comply with the requirements of unity of invention.

INTERNATIONAL SEARCH REPORT
Information on patent family members

06/08/97

International application No.
PCT/SE 97/00497

Patent document cited in search report			Publication date	Patent family member(s)	Publication date
US	5257415	A	26/10/93	JP 4291832 A	15/10/92
				JP 4292024 A	16/10/92
EP	0395239	A1	31/10/90	CA 2011483 A,C	24/10/90
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				EP 0712373 A,B	22/05/96
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EP	0735668	A1	02/10/96	CA 2171122 A	01/10/96
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WO	9636105	A1	14/11/96	NONE	

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